JUPOS/BAA interim report [2015 July 6]:

<u>The SEBs in 2014/15</u>

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Whereas the SEBs edge showed no large anomalies this apparition, hi-res images revealed a wealth of small-scale detail on it, and JUPOS measurements revealed a wide range of speeds. Results of our detailed analysis can be summarised as follows. Most features had speeds close to the ZWP, although their appearance varied between different sectors. They included rings (vortices) with full jet speed, up to DL2 = +121 deg/month, i.e. typical jetstream spots. However there were also wave-like features at the same latitude as the jet peak with much slower retrograding speed, which appear to be waves whose phase speed is much less than the wind speed. This is the fourth time that we have observed such wave phenomena on this jet: the previous occasions were in 2010-2011 in a wide range of different atmospheric conditions before, during, and after the SEB Revival.

In 2014/15, the SEB was generally normal. In 2015 Jan., the GRS was at L2 = 223, with the usual rifting f. it up to L2 ~ 270. This rifted region contracted to almost nothing during Feb.; so on any given date in late Feb. and early March there was only one tiny bright spot immediately f. the GRS, or none at all [see our image compilations, which include resolved details circulating in the GRS]. During March the number and scale of these white spots gradually expanded again, and by May the rifted region had returned to its usual complexity with several white spots at once.

Following the rifted region the SEBs was chaotic with large dark patches, gradually resolving into spots. The remaining sector, comprising ~180 deg. p. the GRS, was where distinct spots, rings, and waves were observed. All these features, including the vortices and the waves, were visible in the first hi-res images of the apparition from mid-Oct. onwards. Our hi-res analysis covers 2015 Jan. to March, as shown in the figures: a complete set of strip-maps; a detailed JUPOS chart; and a ZDP.

[On Jan.24.2, HST took two images (publicly released), showing the triple transit and the SEBs wave-train at higher resolution. Efrain Morales Rivera took hi-res images at the same time, which we have used for this report.]

The features on the SEBs can be categorised in six groups A to F, as follows (see Table, *at end*).

A (Spots d4-d7): Dark spots in the STropZ, mostly p. the GRS, in 2014 Oct-Nov. Tracks uneven but nearly stationary.
In 2015 Jan-Mar., instead, there were several near-stationary white areas in STropZ, with DL2 = +6 to +8 deg/mth. They were very bright, but diffuse, so there were only a few points for them on the regular JUPOS chart. They are obvious on the strip-maps (Fig.1). Note disruption as d3 crosses these white areas on Feb.20 and Mar.5.

B (d3, d8-d10): Dark condensations on SEB(SS), modestly retrograding, fitting the ZWP.

C (R8, R9, R10, R18, R19, R20; *w8 etc. in our earlier notes*): Prominent rings on SEB(SS), presumably anticyclonic vortices (classical jetstream spots). Despite their southerly latitude they have full jet speed, averaging DL2 ~ +114, and thus lie above the ZWP. This is exactly what we have found for such vortices in many apparitions since 2005. (One dark condensation on SEB(SS), d16, also belongs to this group.) One pair merged around Jan.30, then it entered the RSH on Feb.7, and was shredded as it moved around the RSH up to Feb.10. Later, R9 entered the RSH on Feb.20; and R18 on March 7-8. (We have image compilations of these.)

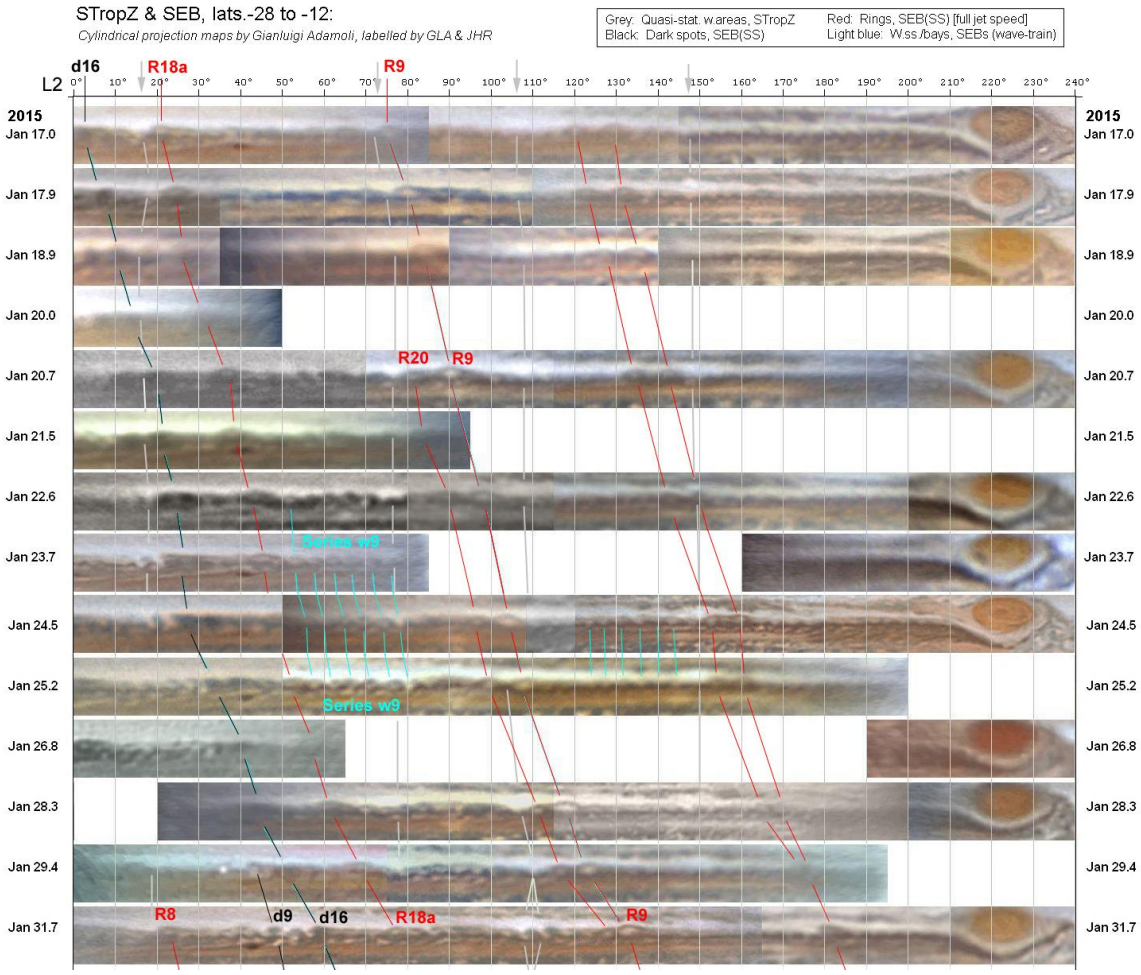
D (d11-d15, w1-w7): The remarkable wave-train on SEBs, wavelength ~5 deg., consisting of white bays alternating with dark humps from SEB(S). The mean speed of DL2 = +84 is much slower than the peak of the jet, although in the same latitude. See below for further comments.

E (d2, d18-d21): Dark spots in the sector f. the GRS, showing full jet speed in the proper latitude. (w11 belongs here as well.)

F (w12-w17): Tiny white spots just N of the narrow SEB(S), difficult to track, but fitting the ZWP.

The wave-trains (Group D) were present over ~180 deg. longitude p. the GRS, where the SEB itself was quiet. The wave-trains were especially regular p. the rings R8, and R18, and R9 and its companion, and p. the unnamed pair of rings at higher longitude. Thus the waves appeared to be induced in the wake of these more-rapidly-retrograding vortices.
Although the images often suggested that the hollows contained tiny white ovals (which were the features tracked), these were not as symmetrical as they appeared, as their dark southern 'caps' in the SEB(SS) moved at a different speed, according to v-hi-res images (Jan.24-25, Feb.7-8, Mar.2-3). Also, they were often disturbed when passing the quasi-stationary white areas (group A) or being overtaken by other rings (group C), which all overlapped in latitude.

Such wave-trains were not generally present in the 2012/13 and 2013/14 apparitions, although they were occasionally imaged in 2012/13. JHR speculates that they may have appeared now because of the reduced activity in the post-GRS rifted region, which may have reduced the turbulence on the SEBs jet – although activity has never been absent and there are always vortices on the jet. Possible explanations will be considered in more detail in our paper on the waves from 2010 to 2015.



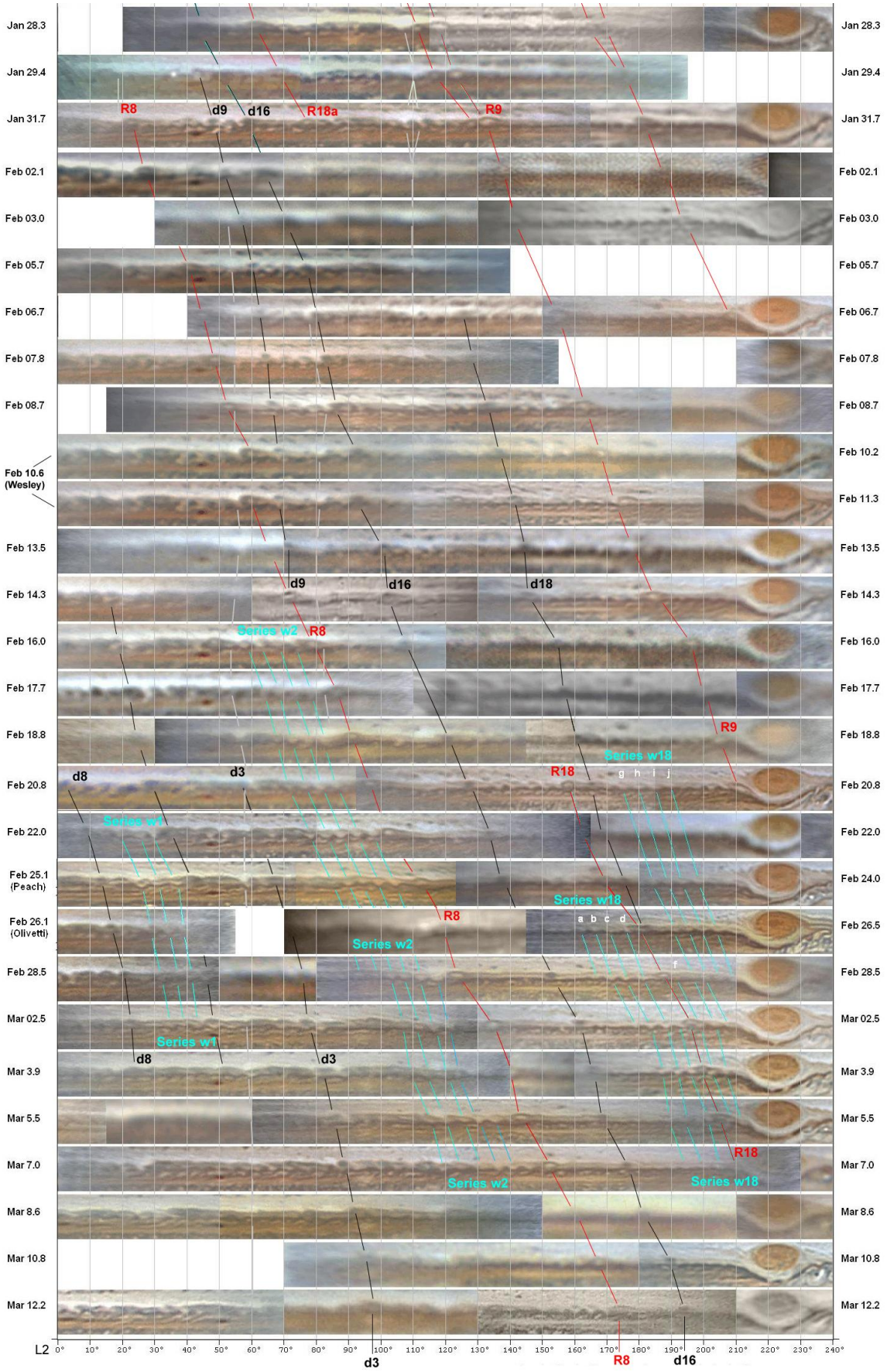
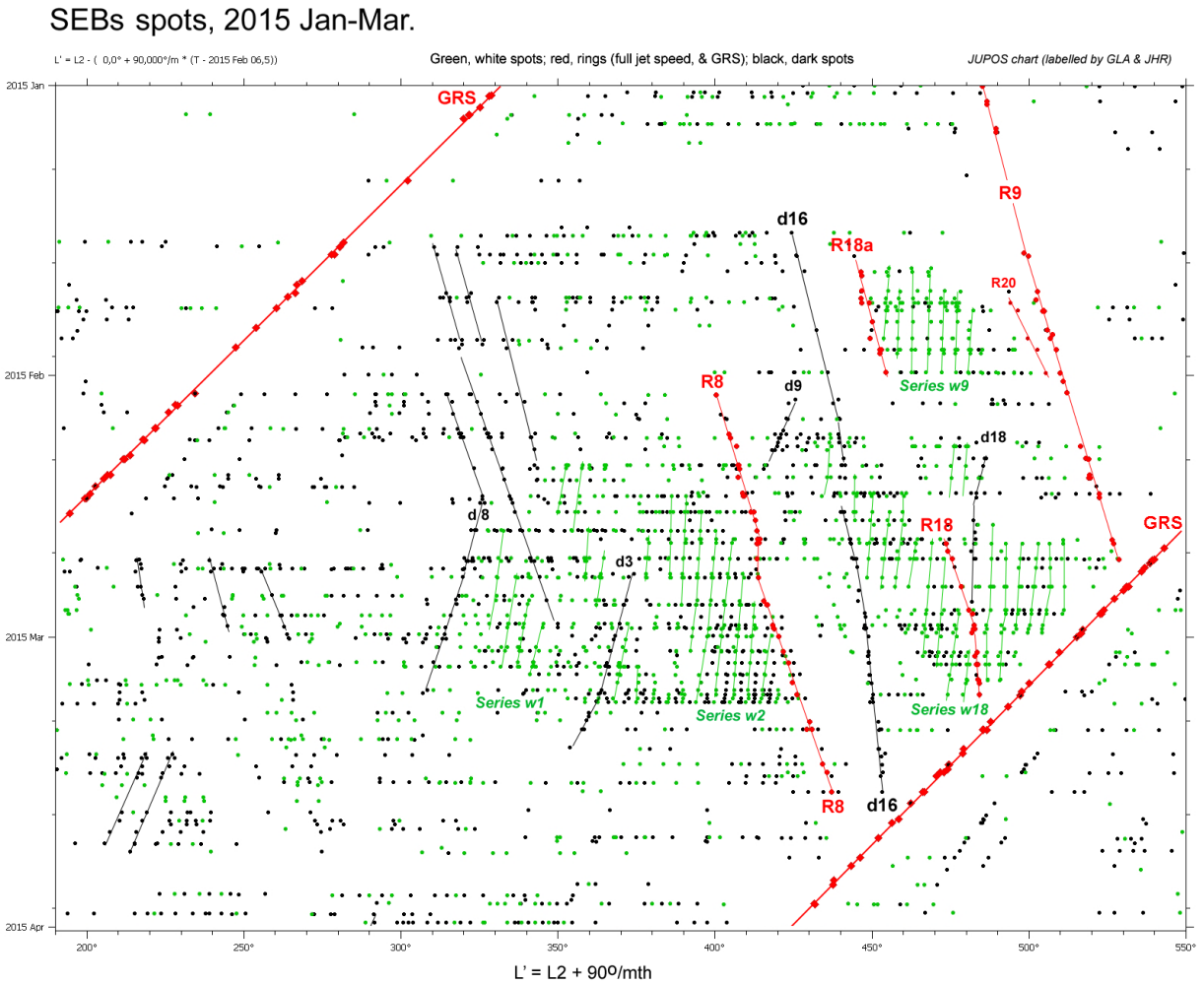


Fig.1. Strip-maps of the SEB. (South is up.)



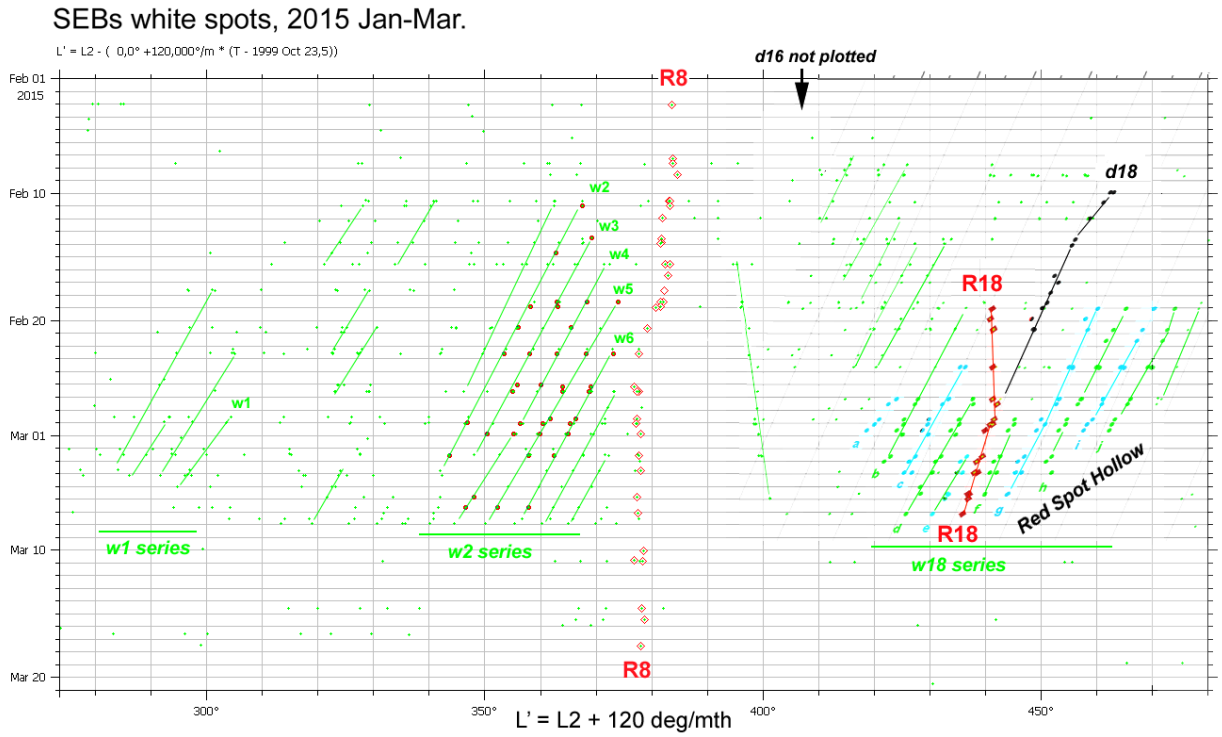


Fig.2. JUPOS charts (analysis by G.Adamoli). Top: All data, Jan-Mar.
Bottom: Enlargement showing white spots in Feb-Mar.

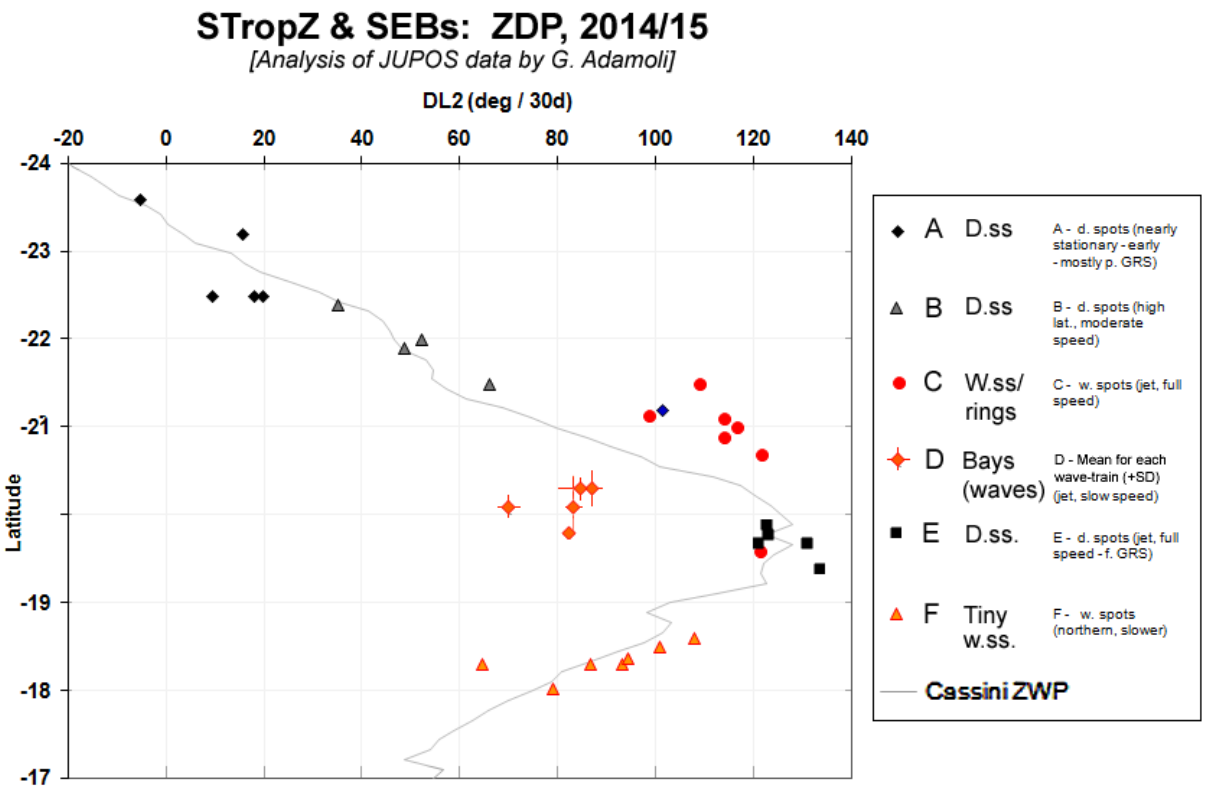


Fig.3. Zonal drift profile.

2014-15 SEBs spots (latitude -23 to -17)

(JUPOS data - GA analysis)

Current	*spot no.*	*description*	*Lat.*	*N*	*L2(0) (Feb 6)*	*ΔL2 (deg/30d)*	*Dates*	*notes*
A -- Dark spots	d1	d. spot / proj.	**-23,2**	24	224	**15,4**	Mar 3 - 18	F. GRS; slightly accelerating aftereward
Nearly stationary								
Early. Mostly p. GRS	d4	d. spot / proj.	**-22,5**	11	139	**9,2**	Oct 18 - Dec 7	
	d5	d. spot / proj.	**-23,6**	20	130	**-5,6**	Oct 10 - Nov 15	Progressively migrating N.ward
	d6	d. spot / proj.	**-22,5**	7	240	**19,5**	Oct 4 - 25	Accelerating afterward
	d7	d. spot / proj.	**-22,5**	8	14	**17,8**	Oct 23 - Nov 1	Irreg. motion, or scattered measures?
B -- Dark spots	d3	d. proj.	**-22,4**	9	56	**34,9**	Mar 6 - 19	
High latitude;								
(moderate speed)	d8	d. spot / proj.	**-21,5**	12	332	**65,7**	Feb 14 - Mar 1	Decelerating afterward
	d9	d. spot / proj.	**-21,9**	13	62	**48,5**	Feb 3 - 13	
	d10	d. spot / proj.	**-22,0**	6	58	**52,1**	Mar 16 - 28	
C - White spots	R8	w. spot with d. ring	**-20,7**	14	37	**121,4**	Feb 22 - Mar 17	
Jet, full speed								
	R9	w. spot with d. ring	**-21,1**	8	154	**113,8**	Dec 25 - Jan 6	
			-21,0	20	155	**116,3**	Jan 18 - Feb 14	
	R10	w. spot with d. ring	**-21,5**	8	155	**108,6**	Oct 17 - Nov 2	
	w11	*w. spot*	***-19,6***	*10*	*301*	***121,1***	*Nov 1 - 23*	*Belongs with group E.*
	R18	Ring (SPTR)	**-21,15**	11	116	98,4	Feb 27 - Mar 7	[Amended] After merger with d.s.
	R19	ring	-20,9	12	99	**113,6**	Jan 20-31	
C -- D.s.: Jet, full speed	d16	d. spot / proj.	**-21,2**	38	79	**101,4**	Feb 3 - Mar 17	Latitude progressively decreasing?
D - White spots (bays)	Series w1:	**Mean:**	**-20,1**	7-11		**69,8**	Feb 17 - Mar 5	No. of waves measured:
Jet, slow speed		*(SD)*	*(0,14)*	*per spot*		*(2,5)*		W.ss.(5)
	Series w2:	**Mean:**	**-20,1**	7-12		**83,0**	Feb 10 - Mar 7	No. of waves measured:
		(SD)	*(0,33)*	*per spot*		*(1,6)*		W.ss.(4) & d.ss.(5)
	Series w9:	**Mean:**	**-20,3**	9-13		**86,7**	Jan 20 - 31	No. of waves measured:
		(SD)	*(0,21)*	*per spot*		*(1,6)*		W.ss.(7)
	Series w18:	**Mean:**	**-20,3**	8-14		**84,4**	Feb 19 -Mar 7	No. of waves measured:
		(SD)	*(0,12)*	*per spot*		*(4,1)*		W.ss.(9)
	w7	w. spot	**-19,8**	10	349	**82,0**	Jan 17 - Feb 10	
E -- Dark spots	d18	d. spot	**-19,7**	12	234	**130,7**	Feb 12 - Mar 3	
Jet, full speed								
(f. GRS)	d19	d. spot	**-19,7**	7	279	**120,8**	Feb 7 - 24	
	d20	d. spot	**-19,8**	12	318	**122,8**	Feb 3 - 24	
	d21	d. spot	**-19,9**	12	327	**122,5**	Feb 3 - 17	Decelerating at end?
	d2	d. spot	**-19,4**	7	224	**133,2**	Feb 12 - Mar 9	
F - White spots	w12	w. spot	**-18,3**	9	316	**64,2**	Nov 10 - Dec 20	
Northern, slower								
	w13	w. spot	**-18,6**	10	35	**107,6**	Jan 16 - 26	
	w14	w. spot	**-18,3**	13	66	**92,9**	Jan 31 - Mar 7	Oscillating?
	w15	w. spot	**-18,5**	6	79	**100,5**	Feb 27 - Mar 17	
	w16	w. spot	**-18,4**	9	308	94,0	Feb 21 - Mar 1	
	(update)	w. spot	**-18,0**	7	319	78,7	Mar 2 - 9	
	w17	w. spot	**-18,3**	9	317	**86,4**	Feb 21 - Mar 16	Oscillating?